

Gaining Gasification Ground

Companies focused on producing liquid fuels via biomass gasification are making noteworthy progress.

By Keith Loria | October 07, 2013

Project Alpha in North Carolina is going to commercially test a broad range of purpose-grown energy crops.

Chemtex International Inc. received a \$99 million conditional loan guarantee from the USDA a year ago, along with a \$3.9 million grant from the USDA through the Biomass Crop Assistance Program, to help establish 4,000-plus acres of miscanthus and switchgrass across 11 North Carolina counties to help supply the new facility. “The Chemtex project in Clinton, N.C., will use a multifeedstock strategy including switchgrass, high biomass sorghum and arundo donax, as well as select hardwood tree species, miscanthus and Bermuda grass residuals,” says Mark Conlon, vice president of sector development for the Biofuels Center of North Carolina.

The push for renewables has fast-tracked the strategic thinking of several biomass companies that have turned to biomass resources to explore the viability of gasification for liquid fuel, fertilizer and chemical production. All in various stages of development with significantly different technology platforms, each have many common goals, which include low feedstock and operating costs, compatibility with the current fuel infrastructure and maximum yield achievements.

One such company making a name for itself in the sector is KiOR Inc., a six-year-old company focused on converting biomass into a renewable crude.

Drop-in Fuels

KiOR Inc. was founded in 2007 by Khosla Ventures and a group of catalyst scientists who were looking for opportunities to produce renewable fuels from cellulosic biomass. Using a one-step catalytic process, the company developed a means to convert abundant nonfood feedstocks into a renewable crude oil. Using standard refining techniques, the renewable crude oil could be processed into fuels that can drop seamlessly into the existing fuels infrastructure.

The company validated the technology and feasibility of the process at its pilot plant in Pasadena, Texas, and subsequently scaled up 400 times in a demonstration unit. It then built a 13 MMgy cellulosic fuel production facility in Columbus, Miss., which commenced shipments of cellulosic gasoline and diesel in 2013.

KiOR’s technology is feedstock flexible and has successfully tested a number of different

biomass sources. Its Columbus facility is focused on southern yellow pine, which is in abundant supply and has a relatively stable pricing history. “We are beginning to see traction on the commercial development of feedstocks other than southern yellow pine, including hardwood, energy crops and waste products such as railroad ties, all of which we expect to be able to procure at lower costs without negatively impacting the overall growth-to-drain in the basin,” says Fred Cannon, KiOR president and CEO. “This has never been done commercially, so KiOR is charting new territory. We have encountered the normal challenges that any startup company would, but are building our on-stream percentage and getting more fuel on the road.”

High Pressure, High Throughput

Conversion technologies for syngas derived from fossil fuels are proven and, in many cases, commercially viable to produce fuels and chemicals. Most, if not all, of the conversion technologies operate at high pressure. The challenge has not been making these materials but making them economically.

Duane Goetsch, chief technical officer for Elk River, Minn.-based SynGas Technology LLC, says the focus of SynGas Technology involves the development of a high-pressure, high-throughput gasifier for biomass. Building a modular gasifier island will leave few opportunities for future modifications to reduce costs, Goetsch says. “For this reason, we have developed biomass gasification technology that operates at higher pressure (about 25 standard atmosphere) and significantly shorter residence times than competing technology.”

SynGas Technology approached the gasifier design from the vantage of taking virgin biomass and producing synthesis grade syngas. This has led to several unique and proprietary features, which involve syngas that meets the end users specifications regarding the ratio of H₂-to-CO, contaminant levels and duty factor with respect to time on stream.

“To do this, we’ve developed a proprietary feed system that modifies the composition and morphology of the virgin feed and provides significantly reduced sizing costs, reduced tar and soot made in the gasifier, improved methane selectivity, and significantly improved duty factor of the feed system,” Goetsch says. “We also have a proprietary oxygen injection system that reduces temperature gradients in the injector region. This mitigates the formation of slag in the gasifier.”

SynGas Technology makes use of a circulating solid system that integrates the gasifier with a fluid bed combustor to further take advantage of the differences in slagging propensity of inorganic material in biomass between the oxidizing environment of the combustor and reducing environment of the gasifier. The system is designed to take advantage of cellulosic feedstock and can handle feedstocks from agricultural residuals to woody biomass.

The company has also developed a proprietary, hydrothermally stable, circulating solid catalyst that efficiently transfers heat into the gasifier and provides methane reforming activity and partitions sulfur between the syngas and flue gas streams. This design also reduces the amount of oxygen used in the process—since air can be used in the

combustor—and gives lower CO₂ content in the syngas stream, which reduces downstream CO₂ removal costs. Overall, the gasifier has a thermal efficiency of 90 percent and a carbon efficiency of 51 percent.

This technology traces its roots to the Exxon Advanced Gas Conversion Process developed in the 1980s and 1990s. The gasifier section makes use of similar fast-fluidized bed technology and builds on the original catalyst development. The technology team was reassembled in 2007 at SGT, and it has been advancing the technology using biomass at pilot scale. The company estimates capital costs savings associated with the gasifier island of \$50 million to \$100 million and operating costs savings of about 20 percent compared to lower pressure gasification.

“We are currently raising funds to build a demonstration facility in northern Minnesota. We anticipate that \$25 million will be needed to build and operate the facility and we’re at about 40 percent of our goal,” Goetsch says. “Our objective is to complete the data package necessary to generate process guarantees and information needed to minimize or reduce costs associated with the wrap of a commercial scale facility.”

Green Gasoline

The most obvious challenge of using biomass for gasification is that it is an inferior feed compared to natural gas or petroleum-derived fuels. It is hydrogen deficient and the high oxygen content is undesirable, considering fuels are basically composed of chains of carbon and hydrogen.

Gasification of biomass produces lower-ratio syngas, typically 1.0-to-1.5. Conversion processes that produce fuels typically require ratios around 2-to-1. The higher ratio can be achieved by using more steam in the gasifier or incorporation of water-gas-shift technology, but both result in lower thermal efficiency and reduced carbon efficiency, which directly translates into lower product yield and higher cost.

As an entry into gasification of biomass, Sundrop Fuels Inc., in Longmont, Colo., is constructing its inaugural facility near Alexandria, La. The combined commercial and demonstration plant will annually produce about 60 MMgy of finished gasoline from natural gas while providing the platform for Sundrop Fuels to prove its proprietary gasification technology of making renewable “green gasoline” from woody biomass.

“At the center of our advanced biofuels production is the Sundrop Fuels proprietary, ultrahigh-temperature pressurized gasification system. Inside a specially designed thermochemical reactor, woody biomass is quickly converted using indirect radiation heat transfer to rapidly drive the extremely high temperatures needed,” Steven Silvers, a spokesman for Sundrop Fuels, says.

“Hydrogen from natural gas is added as a secondary feedstock, combining to create a renewable feed stream that is the key ingredient for our biogasoline, which is 100 percent compatible with today’s combustion engines and transportation fuels infrastructure.”

At a molecular level, Sundrop’s biogasoline will be the same as petroleum-based gasoline. The renewable feed stream is then converted to methanol, and then to gasoline using commercially established processes.

Sundrop Fuels' innovative production method represents a number of patents resulting from work done over many years, culminating with a research and development site that Sundrop Fuels operated in Colorado. This facility was dismantled and will become part of the new plant in Louisiana.

"What makes our process unique from conventional biomass gasification is that it steadily maintains ultrahigh temperatures to drive the endothermic gasification reaction," Silvers says. "This makes the process operate at extraordinary high efficiency, producing more yield of renewable liquid fuel per ton of biomass feedstock than any other production method. Using natural gas as the power source, temperatures inside the Sundrop Fuels radiation-driven gasifier reach more 1,300 degrees Celsius (2,372 degrees Fahrenheit)—hotter than lava flowing from a volcano."

The use of natural gas to provide additional hydrogen is also a unique aspect. Advanced biofuels production has historically been limited because plant material feedstock has generally about a 1-1 ratio of hydrogen to carbon, while gasoline used in today's combustion engines must have twice as much hydrogen as carbon. To correct this imbalance, Sundrop will add hydrogen obtained from natural gas to the production process, which will result in virtually 100 percent of all the carbon in the plant material being converted into biogasoline.

The company expects to formally break ground on the site at the end of the year and to build several biofuels megaplants over the next decade.

5-Way Collaboration

Earlier this year, Haldor Topsoe Inc. teamed with Andritz Carbona, Gas Technology Institute, Phillips 66 Co. and UPM-Kymmene in completing the first production of gasoline from woody biomass in an integrated 20-barrel-per-day (840 gallons per day) demonstration plant located near Chicago.

Henrik Udesen, business development manager of Haldor Topsoe, explains that the Des Plaines, Ill., plant is gasifying wood pellets into biofuel via the company's TIGAS (Topsoe integrated gasoline synthesis) process. "We supply the technology but we are not directly involved with the gasification ourselves, and are relying on the other companies for that part," he says. "Once the gasifier has produced a syngas, our technology comes into play to convert the syngas gas into something useful."

The combined technologies include gasification by Andritz Carbona, GTI/Uhde's Morphysorb process to capture acid gases, the woody biomass supplied by UPM-Kymmene. Collaborator Phillips 66 Co. is conducting single-engine emission tests and moderate fleet testing of the renewable drop-in gasoline.

"We are ready to help this development, but also realize we're still at the beginning of this and are looking at the importance of working in this field," Udesen says. "Our challenge is to develop new ways to be part of the solution for the future of fuel supply."

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